The Clients

TRIUMF Applied Technology Group (ATG) nordion

ATG is a group within TRIUMF responsible for operating three cyclotrons
45 000 patients per week receive radioisotopes produced by our cyclotrons

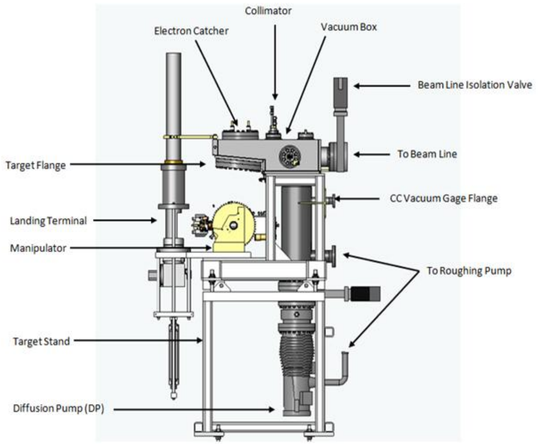
Cyclotron
Accelerates Hydrogen ions to high speeds

The Product

In Nuclear medicine, radioisotopes are used for diagnosis, treatment, and research. These chemicals trace the emitting gamma rays to provide diagnostic information about a person's internal anatomy and the functioning of specific organs.

In producing radioisotopes, radioactive beam needs to be shaped and transformed effectively inside a suitable production station. This is where our project comes in.

The Current Target Station



The Concerns

- Difficult to maintain and service due to target chamber and vacuum box being a single piece
- 48 bolts currently used to seal target chamber and electron catcher
- The use of welding increases the possibility of outgas
- Difficulty in maintenance results in an increase of radiation dose to personnel and safety is compromised

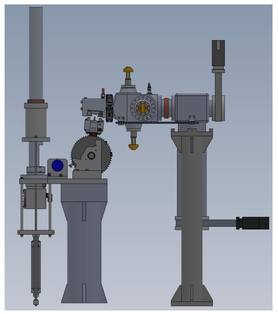
The Project

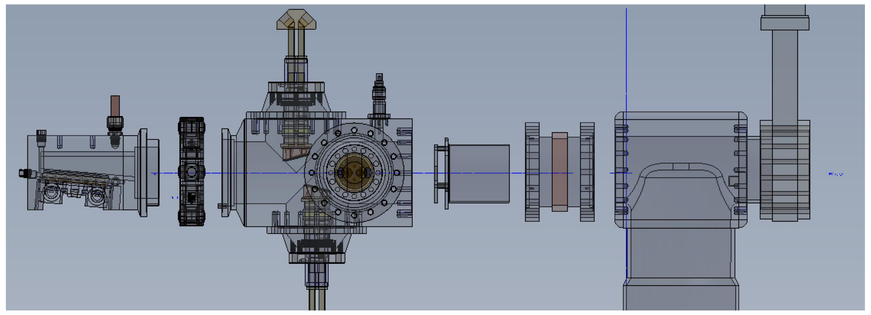
To design an easy to maintain, modular device, which holds targets in a low vacuum environment required for medical isotope production with improved sealing to minimize accrued radiation dose to personnel during maintenance.

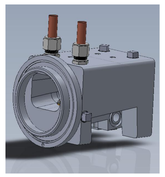
The Bottom Line

SAFETY is our biggest concern throughout the conceptualization and design of this project.

By incorporating modular design, it will allow service personnel to easily and quickly detach components of the target station and service it outside of a high radiation environment.

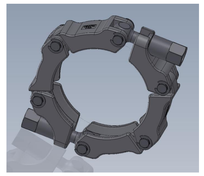






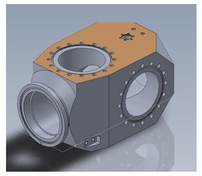
Target Chamber

- Target flange and Electron Catcher are incorporated without the use of bolted connections
- Internal water lines to compensate the increase in temperature during operation



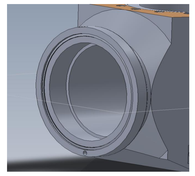
Vacom Chain Clamp

- Integral to our sealing design
- Reduce the number of bolts from 28 to 2 therefore reducing accrued radiation and maintenance time



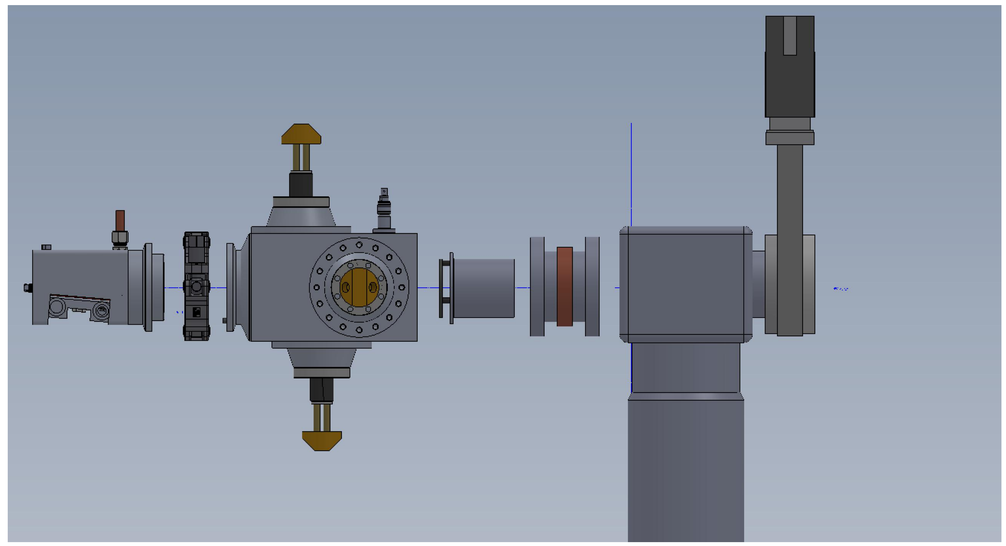
Collimator Box

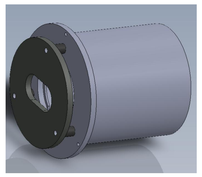
- Machined out of a single-piece 7075 Al
- Incorporates bigger collimator ports with adapters attached
- Ease of installation and flexibility in terms of collimator sizes



Knife Edge

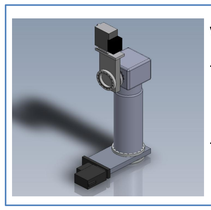
- Machined on Collimator Box as per ISO TS 3669-2007 Standard
- Integral to our sealing design





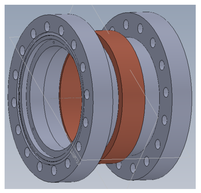
Stray Beam Detector

- Moved to be between Collimator Box and Vacuum Module
- Improved deterrent against misaligned beam protecting critical components
- Shield Ceramic Insulator against metallic decomposition



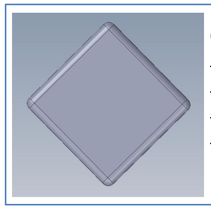
Vacuum Module

- Disconnected and compartmentalized into a separate unit
- Can be maintained and upgraded separately



Ceramic Insulator

- Electrically insulates Collimator Box from Target Station
- Eliminate the need for an Electron Catcher
- Stock part easy to order and replace



Overall Design

- Aluminum Construction
- No Welds
- Modular Design
- Ease of Maintenance

Technical Analysis

Background

As the purpose of this project is to produce a fully defined concept, the use of simulations and testing played an important role in determining the suitability of design features

Simulation

•The use of a simulated Thermal study was completed in order to provide an approximation of the temperature around the immediate target.

Out-Gassing:

•Occurs when gas particles trapped in micro-fissures of a component are released under vacuum conditions (usually)

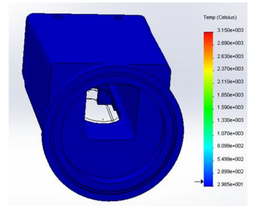
•If Out-gassing effect is large enough, system may act like a virtual leak.

•Out gassing effect is dependant on both material vapor pressure and temperature.

Thermal seal Damage:

•Due to irradiation process, targets dissipate beam energy in the form of released heat

•As a o-ring is utilized to seal the target in for the duration of target run, thermal setting is a concern.



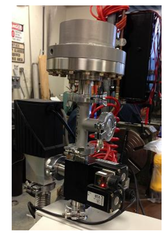
Max Temp Target Chamber Temp: 126 Degrees Celsius

Physical Testing

•As Aluminum was selected to be the material of choice, determining the ability of this material to be utilized for a metal to metal seal was important in mitigating risk associated with this decision.

Vacuum Testing:

•A test of the re-usability of an Aluminum CF flange was performed in order to determine the wear of the knife edge after the first seal was performed



Hardness Testing:

•Utilized to obtain qualitative data with regards to the wear of the knife edge between each seal

•Also used to determine the relative hardness between in-house annealed and non-annealed aluminum samples in order to gauge the effectiveness of this operation in producing a viable gasket material

Gasket and Annealed Material Hardness Testing

Conclusions

Safer Design

- All aluminum construction: Lower Residual Radiation
- Modular design: Quick Assembly/Disassembly

More Efficient Design

- Welds eliminated: Lower Outgassing; Lower pump-down times
- Upstream Electrical Insulation: Elimination of Electron Catcher
- Machined CF Flanges: Elimination of expensive weld-on Atlas Flanges

Future Flexibility

- Collimator Adapters: Collimator changes acceptable.
- Better Water Cooling: Higher Energy Beams acceptable.

Minimized Infrastructure Changes

- Retained old target delivery and retrieval setup.
- Retained old pump

Recommendations

Newer Sealing Technologies

- Delta Helicoflex Seals: Lower Clamping Forces; Multiple Uses

Surface Coatings

- TiN Coating: Knife edge wear Resistance; Reduced Secondary Electron Emission

Further Testing

- Vacom Chain Clamp
- Water Cooling: Manifolds for water lines.

Future Student Project